1090-WP-11-02
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RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #11

Action Item 10-10
RMF Enhanced Decoder Re-triggering Algorithm Description

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SUMMARY
In response to Action Item 10-10 this paper contains a detailed description of the re-triggering algorithm used by the RMF enhanced decoder to produce the reception performance shown in Figure 3 in 1090-WP-10-16.

RMF ENHANCED DECODER RE-TRIGGER PROCESS

Introduction

The RMF Enhanced Decoder has the ability to re-trigger on an incoming signal when a preceding signal is already in progress. When re-triggering occurs, the new signal must meet all the conditions for a valid preamble and pass the preamble validation test, but in addition, the amplitude of the new signal must exceed that of the signal in process by at least 3 dB. When this occurs, processing is shifted to the new signal and the original signal is lost. As stated in the MOPS, it is desirable to switch processing to the stronger signal since it is likely from a closer aircraft that represents a greater threat, and that the overlapping stronger signal will most likely prevent proper decoding of the original signal. Action item 10-10 is a request to write up a detailed description of the re-triggering algorithm contained in the RMF enhanced decoder. The purpose of this action is to provide input to determine if it is feasible for a real-time implementation of an enhanced decoder to perform as well as the RMF enhanced decoder does as shown in figure 3 in WP-10-16. The specific focus is whether a certain amount of "dead time" must exist from the time when a receiver triggers and when a receiver is able trigger again. To properly examine the RMF re-triggering process, it is required to examine the entire triggering process.

The RMF Enhanced Decoder is software that is used to post-process recorded digitized video data to detect and decode extended squitter messages using enhanced decoding techniques, error detection, and acceptable error correction processes. The software is used for various applications some of which it is desirable to make use of the advantages of non-real time processing to maximize the ability to detect and decode all messages possible. But when the software is used to assess the capabilities of a baseline enhanced decoder under various conditions, it is important that limitations are placed on the process that constrain it to emulate an implementable process. Working paper 3-08 contains a detailed description of the software. Currently the limitations imposed within the algorithm desensitize the receiver when it triggers from any false or real trigger, but they do not impose any complete dead time. The length of time the receiver is desensitized is the duration of the signal or until any built in false trigger indicators terminate processing. (The false trigger indicators are described in WP-3-08) The receiver will be desensitized by an amplitude equal to the reference level of the signal. Any subsequent trigger that occurs within the desensitized period must exceed the previous reference level by at least 3 dB. Following a trigger, the receiver is desensitized, but it is able to trigger again on the very next clock cycle.

The RMF Enhanced Decoder Triggering Process

The RMF enhanced decoder software processes the digitized video signal in stages that relate to the process defined in Appendix I. The RMF triggering process is illustrated in figure 1. The combination of the Preamble detection and Preamble Validation steps will require an input of approximately 130 samples that span from the sample preceding the current potential trigger point to 4 samples past the last possible lead edge location of the 5th data bit (2nd chip). The 130 samples are based on a 10 MHz sample rate that the RMF uses.

Locate Pulses and Leading Edges

The first step in the RMF Enhanced Decoding Process is to locate pulses and their leading edges. Each sample that is above threshold and is followed by 3 or more successive samples above threshold is defined to be a pulse position. A leading edge is a valid pulse position that is 4.8 dB or more greater than its preceding sample and less than 4.8 dB lower than its succeeding sample**.**

Preamble Detection

The digitized video data is continuously shifted into the Preamble Detector until a pulse or leading edge is located in the reference position. When this occurs, the nine video samples that correspond to the nominal leading edge positions of the remaining 3 preamble pulse locations (relative to the reference position) and plus and minus one clock from each are examined to contain pulses or leading edges. If pulses are found in the 3 remaining locations, it is required that there are at least 2 leading edges declared within the + or **-** 1 sample tolerance range of the four pulses with at least one of them in the reference position. The pulse sample timing tolerance is limited to either one sample plus or one sample minus but not both in the same preamble. If there are 2 or more lead edges in either the +1 clock offset or –1 clock offset direction, then the reference position will be shifted in that direction.

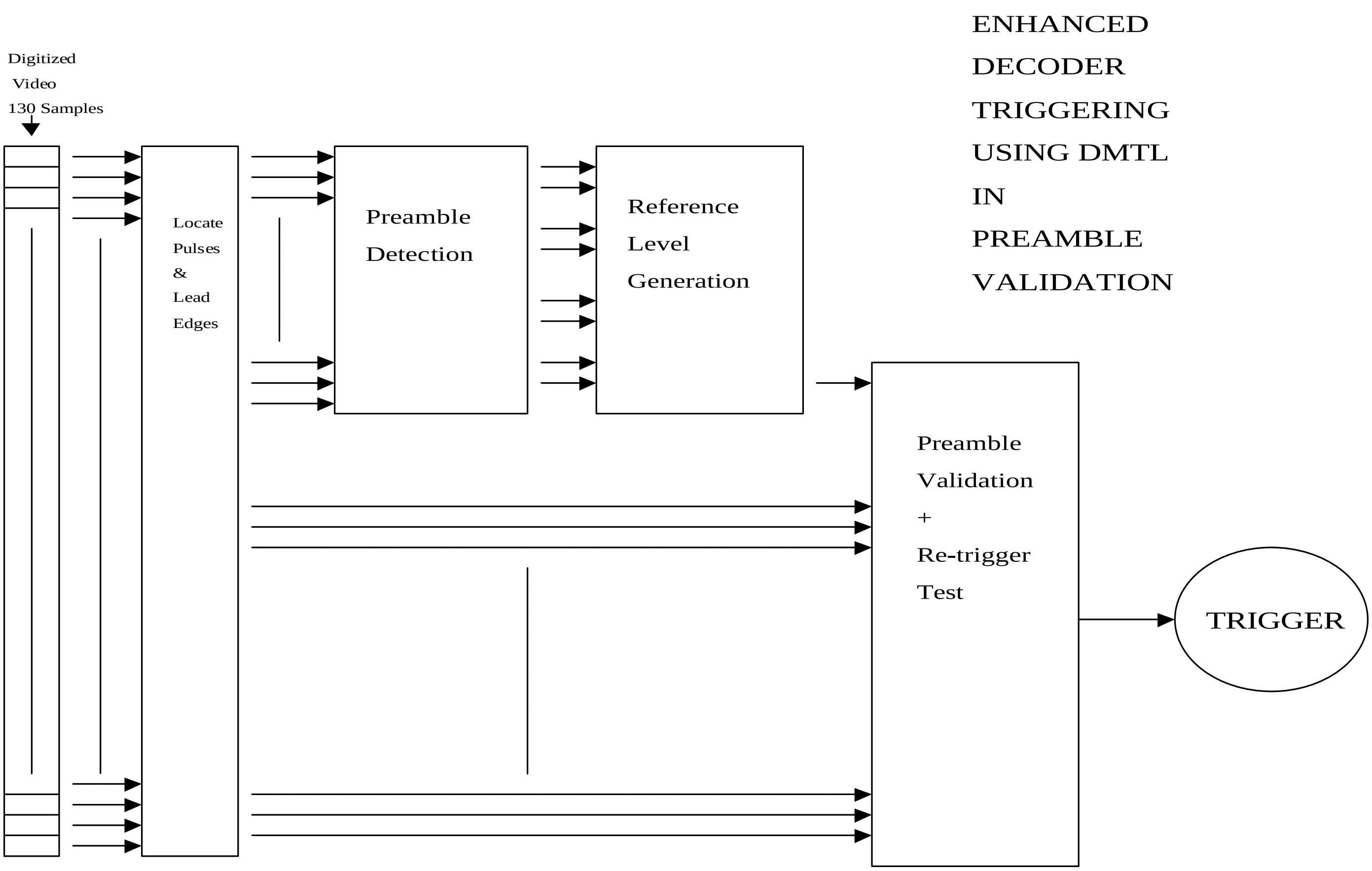

FIGURE 1 – RMF ENHANCED DECODER TRIGGERING PROCESS

Reference Level Generation

The reference level generation process begins by selecting amplitude samples from each of the preamble pulses that are considered appropriate candidates, namely only those that have leading edges declared in their reference positions. The three amplitude samples after each valid lead edge position are entered into the reference level declaration algorithm (up to 12 samples are possible). For each qualified sample, the amplitude is compared to all other qualified amplitude samples and the number that lies within plus or minus 2 dB is counted. If the highest count is unique, then the reference level is set to the amplitude of that sample. If there is a tie, it is resolved by removing all amplitudes from the tied set that are greater than 2 dB above the lowest amplitude in the tied set. The reference level is set to the average of all remaining samples.

Preamble Validation

The RMF Enhanced Decoder uses the reference level established in the previous step to set a dynamic threshold at 6 dB below the reference level for Preamble Validation. Preamble Validation proceeds to examine the samples within + or – 1 clock of the expected location of the lead edges of the first 5 data pulses (both bit halves). A leading edge or pulse must be located in either chip of all 5 data pulses, and the amplitude of the pulse must meet or exceed the dynamic threshold.

The Re-trigger Test

The timing and reference level of the last trigger is stored. If the timing of the current trigger is such that it has occurred anywhere within the time-span of the previous trigger or complete signal, the current signal must meet certain amplitude criteria to proceed as a valid re-trigger. In this case, the current reference level, and the peak amplitude of <u>all</u> 5 of the data pulses must be at least 3 dB greater in amplitude than the reference level of the previous trigger. If the criteria for re-triggering is met, the new signal is passed to the Bit and Confidence Decoding process, the message that was in process is cancelled, and the receiver is now even further desensitized to any subsequent triggers. If the criteria for re-triggering is not met, the new trigger is ignored. In either case, the whole process will continue with the next sample, hence, no dead time.

Other Implementation Considerations

The algorithm described above for the RMF Enhanced Decoder, is a variation of the basic enhanced decoder process that is defined in the MOPS. The fact that the Reference Level Generation Step precedes the Preamble Validation step was done so that the reference level could be used to set up a dynamic threshold as additional criteria for preamble validation. The purpose of this was to mitigate the effects of false early triggers caused by low level fruit combining with the first 2 preamble pulses. This is a phenomenon that was observed in higher fruit environments like Frankfurt. However, this re-ordering of processes places the Reference Level Generation step in series with the Preamble Validation step. This could (but not necessarily) increase processing time that could introduce or increase a potential dead time if it is decided that one can not be avoided. An alternative process could look like that in figure 2. The process depicted in figure 2 is more like the conventional approach documented in appendix I. The advantage here is that the Preamble Detection and Preamble Validation processes are done in parallel. A “False Trigger” test was added to the Preamble Detection step to replace the Dynamic threshold used in the RMF method. The False Trigger test could compare amplitudes of the preamble pulses and reject those that have too great of a variation between pairs. The specifics of this False Trigger test are unknown, but some type of implementation would likely be required to produce the same performance as the RMF Enhanced Decoder.

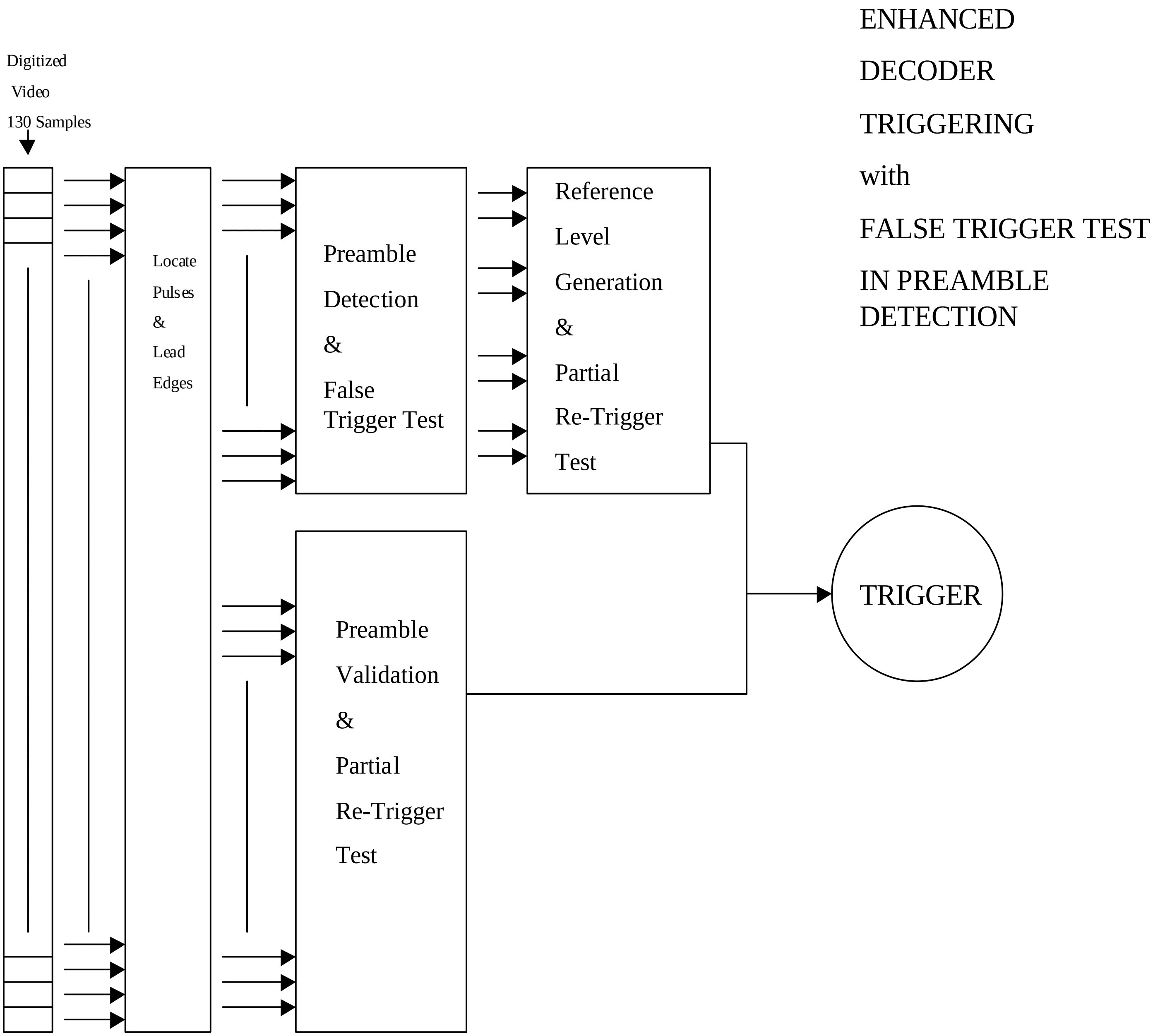

FIGURE 2 – CONVENTIONAL ENHANCED DECODER TRIGGERING PROCESS